

Naval Safety Center Aviation Maintenance Safety Conference 2005



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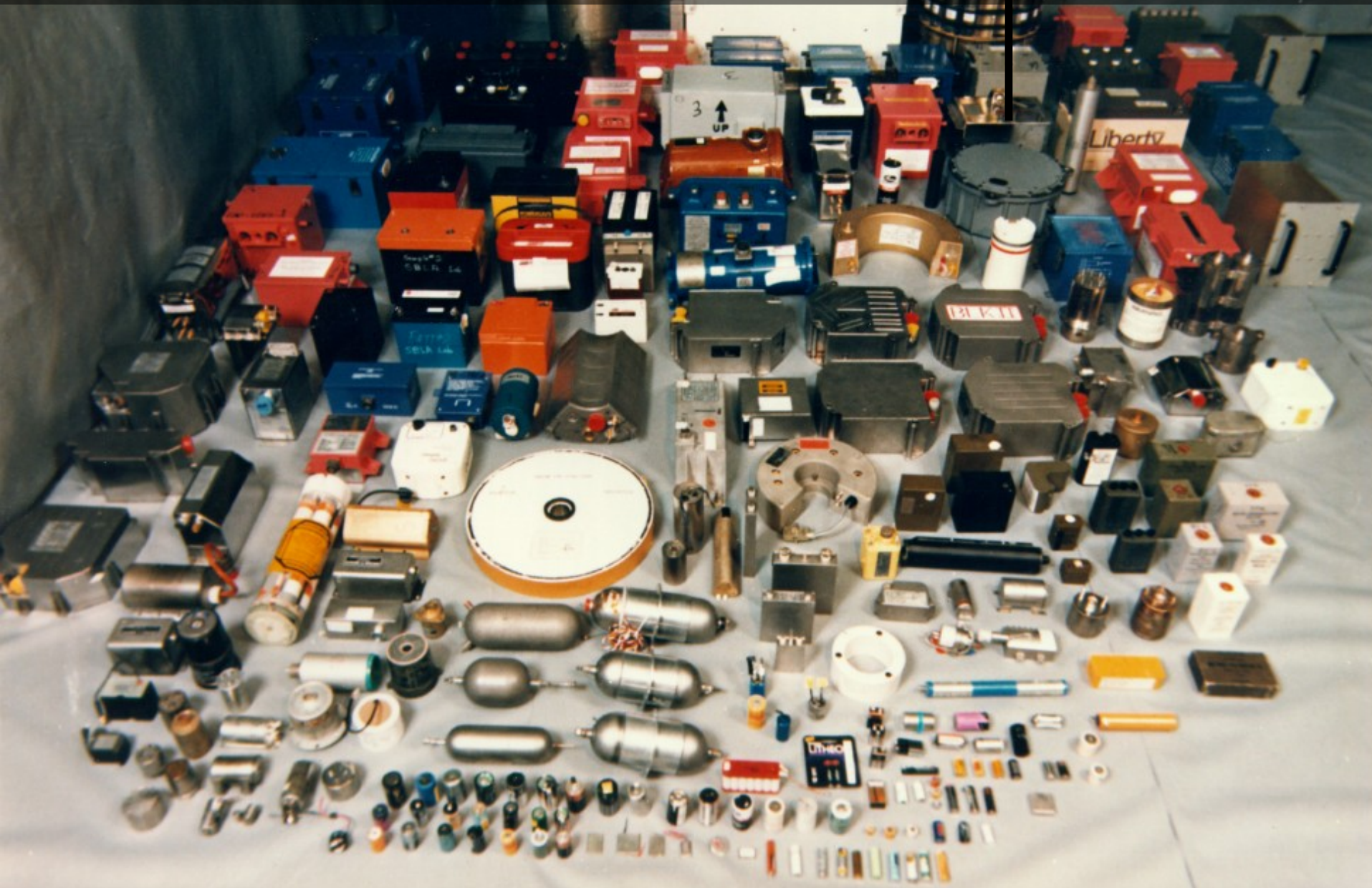


Lithium Battery Safety Program

Outline of Presentation

- **Introduction and Background on Lithium Batteries**
- **History of the Lithium Battery Safety Program (LBSP)**
- **Process for Lithium Battery Safety Approval**
- **LBSP and WSESRB Relationship**
- **Conclusion and Questions**

Batteries are produced in all shapes and sizes. Each has specific volumetric and power capabilities.



To meet the mission electrical, environmental, size and weight requirements.





Lithium Battery Safety Program

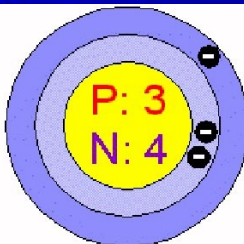
Lithium Facts:

- Element with Atomic Number 3
- Lightest Alkali Metal ($\rho=0.53 \text{ g/cm}^3$)
- Silvery, Metallic Solid at Room Temp
- Very High Thermal and Electrical Conductivity
- Highest Specific Heat of any Solid Element
- Source - Salts & Hydrates
- Melts at 180.5 C (357.0 F)
- Reacts with Water
- Burns in Air
- Very High Electrochemical Potential
- Extremely Mobile +1 Ions

ALKALI METALS

Lithium
 Sodium
 Potassium
 Rubidium
 Cesium
 Francium

ates



6.94 Atomic Weight

H	He																	He
Li	Be																	Ne
Na	Mg																	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub							
			La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
			Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	



Lithium Battery Safety Program

Lithium Uses and Applications



Non-Energetic:

- **Lithium Citrate Used in the Original 7-Up Soda (Original Name, ~1929, was “Bib-Label Lithiated Lemon-Lime Soda”)**
- **Lithium Carbonate Used As Anti-Depressant Drug**
- **Lithium Compounds Used in the Production of Aluminum from Oxides (Enhances conductivity for electrolysis of Al_2O_3)**
- **Li-Al Alloys Used in Lightweight Structural Applications (Aircraft)**
- **Lithium Oxides and Fluorides Used in Glasses and Ceramics (Mt. Palomar Telescope)**
- **Lithium Stearate Used in All-Purpose and High-**



Lithium Battery Safety Program

Lithium Cell Types Used by the Navy

- **Primary (Non-rechargeable)**
 - **Active**
 - **Reserve**
 - **Liquid electrolyte**
 - **Thermal**
- **Secondary (Rechargeable)**



Lithium Battery Safety Program

Lithium Cell Chemistries Used by the Navy

- **Solid Cathode -- Li/MnO_2 , Li/CF_x , Li/FeS_2 , $\text{Li/V}_2\text{O}_5$**
- **Liquid Cathode -- Li/SOCl_2 , Li/SO_2 , $\text{Li/SO}_2\text{Cl}_2$**
- **Lithium metal anode**
- **Lithium alloy anode**
- **Lithium ion anode**



Lithium Battery Safety Program

Lithium Cell Sizes

- **Button cell (0.01 Ah)**
- **2/3 AA (0.60 Ah)**
- **1/2 AA (0.95 Ah)**
- **2/3 A (1.20 Ah)**
- **AA (1.90 Ah)**
- **A (2.8 Ah)**
- **9V (1.20 Ah)**
- **1/3 C (0.86 Ah)**
- **2/5 C (2.50 Ah)**
- **C (5.4 Ah)**
- **D (7.2 Ah)**
- **DD (16.5 Ah)**
- **Specialty design cell (2,200 Ah)**
- **10,000 Ah prismatic cell**



Lithium Battery Safety Program

Where Lithium Batteries Are Used in the Navy

- **Communication Radios**
- **Mine Countermeasures Decoys**
- **Locator Beacons**
- **Memory Back-Up**
- **Emergency Signal Devices**
- **Missile Guidance & Control**
- **Laser Detection Devices**
- **Propulsion**
- **Night Vision Goggles**
- **Expandable Training Devices**
- **Aircraft**
- **Mines**
- **Electronic & Acoustic**
- **Sonobuoys**
- **Deep Ocean Sensors**
 - **Transponders**
 - **Telemetry Systems**
 - **Small UUV**
- **Laptop Computers**



Lithium Battery Safety Program

Common Safety Devices for Lithium Batteries Include:

- **Electrical fuses**
- **Thermal fuses**
- **Diodes (charging and bypass)**
- **Voltage monitors**
- **FETs**
- **Vent structures**
- **Fuseable separators**



Lithium Battery Safety Program

Lithium Battery = Stored Chemical Energy

- **Controlled release of this energy provides electrical power in the form of current and voltage**
- **Uncontrolled release of this energy can result in fire, exposure of toxic materials, shrapnel, high pressure events, and any combination thereof**



Lithium Battery Safety Program

- **NAVSEAINST 9310.1A of 11 March 1982**
- **NAVSEANOTE 9310 of 11 June 1985**
- **NAVSEAINST 9310.1B of 13 June 1991**
- **Technical Manual for Batteries, Navy
Lithium Safety Program And Procedures
S9310-AQ-SAF-010 of 19 Aug 2004**



Lithium Battery Safety Program

S9310-AQ-SAF-010

- **Introduction**
- **Selection and review**
- **Design**
- **Use**
- **Packaging**
- **Storage**
- **Transportation**
- **Disposal**
- **Emergency response procedures**
- **Safety and performance tests for certification**
- **Pass fail criteria**
- **Safety**



Lithium Battery Safety Program

General

- **Lithium battery safety approval is specific**
- **Approval not transferable**
- **Partially discharged batteries in system**
- **Removed lithium batteries upon completion of useful life**
- **All ventings, accidents, and incidents involving lithium batteries shall be reported In Accordance With (IAW) the current version of OPNAVINST 5102.1, "Mishap Investigation and Reporting."**
 - **Reports shall also be sent to Naval Ordnance Safety and Security Activity (NOSSA)**



Lithium Battery Safety Program

General (cont)

- **Rechargeable batteries shall only be charged or conditioned using the charging system described in the safety data package**
- **Designated charging protocols must be followed exactly**
 - **Charging regimes or hardware designed to "fix" damaged or failed batteries or cells not described in the safety data package shall not be used**
- **In the event of a known charging system failure, no attempts shall be made to recharge or reuse the battery**



Lithium Battery Safety Program

Packaging for Transportation

- **Department of Transportation are contained in 49 CFR 173.185**
- **Packaging not conforming to 49 CFR 173.185 must be reviewed by Naval Weapons Station (NAVWPNSTA) Earle in conjunction with NOSSA**
- **NAVSEASYS COM is authorized to issue a Certificate of Equivalency (COE) pursuant to NAVMATINST 4030.11**
- **Special overpack mandated by paragraph h (3) of 49 CFR 173.185 such as DOT 17C or DOT 17H drum (or equivalent) equipped with a gas-tight gasket**



Lithium Battery Safety Program

Storage

- **Lithium battery storage aboard submarines shall be approved by NAVSEA SEA-07T**
- **Lithium battery storage aboard aircraft shall be approved by NAVAIR AIR-4.4.4.1**
- **All lithium batteries and lithium battery-powered equipment shall be stored in compliance with specific requirements stipulated in appropriate equipment documents or IAW base or platform regulations as specified in Standard Operating Procedures**
- **When such documentation is not available, the general storage requirements listed below shall be followed for Naval shore facilities, ships, and vessels:**
 - **Store batteries in a dry, cool (below 130°F (54°C)) ventilated shelter out of direct sunlight**
 - **Use shelter only for the stowage of lithium batteries and equipment containing lithium batteries**



Lithium Battery Safety Program

Storage

- **In the field, avoid covering containers of batteries with a black or dark-colored tarp**
- **Exercise special care in handling and moving containers to prevent crushing or puncturing**
- **Isolate storage area from other hazardous and combustible materials**
- **Keep the battery quantities stored in an area to a minimum**
- **Lithium batteries or lithium-battery-powered equipment with batteries installed shall not be stowed in inhabited areas**



Lithium Battery Safety Program

Storage

- **Segregate battery storage areas**
- **Mark area or shelter appropriately**

**"STORAGE OF NEW LITHIUM
BATTERIES"**

**"STORAGE OF EQUIPMENT CONTAINING
NEW LITHIUM BATTERIES."**

**"STORAGE OF PARTIALLY USED
LITHIUM BATTERIES FOR REUSE"**

**"STORAGE OF EQUIPMENT
CONTAINING PARTIALLY USED
LITHIUM BATTERIES."**

"STORAGE OF USED LITHIUM



Lithium Battery Safety Program

Storage

- Batteries awaiting disposal:**
 - Establish a remote collection point
 - Aboard ships, stow only on the weather decks
 - Store no more than 30 lbs. of used or depleted lithium batteries
 - Store used or depleted lithium batteries no longer than 30 days
 - Do not dispose of or transport lithium batteries with normally generated refuse
 - Turn in or offload at the earliest possible time
 - Do not move or offload batteries during ammunition handling or fueling operations



Lithium Battery Safety Program

Hazardous Waste Storage

NOTE:

A PERMITTED HAZARDOUS WASTE STORAGE FACILITY FOR THE STORAGE OF LITHIUM BATTERIES FOR DISPOSAL MUST BE APPROVED AND LEGALLY AUTHORIZED BY STATE/FEDERAL ENVIRONMENTAL PROTECTION GROUPS BEFORE USE

- **Permit to store hazardous waste shall be applied for through the respective state environmental protection group**
- **Permit shall govern the quantities, duration, safe operation, and overall scope of the storage area**
- **The custodian shall not accept lithium batteries, which are not packaged and labeled correctly**



Lithium Battery Safety Program

Transportation

- **Lithium battery transportation aboard submarines shall be approved by NAVSEA SEA-07T**
- **Lithium battery transportation aboard aircraft shall be approved by NAVAIR AIR-4.4.4.1**
- **Transportation requirements covered by Air Force Interservice Manual 24-204(AFMAN 24-204/TM 38-250/NAVSUP PUB 505/MCO P4030.19/DLAI 4145.3)**
- **Transportation of new or used lithium batteries on public domain is controlled by federal law 49 CFR 172.101 and 173.185**
 - **Exemptions are approved by the Office of Hazardous Material Safety Research and Special Programs Administration, U.S. Department of Transportation**
 - **Transportation of hazardous waste is regulated by 40 CFR 263, which provides for the proper identification of the transporter and manifesting of the waste**



Lithium Battery Safety Program

Disposal

- **Routine disposal of batteries at sea prohibited per 40 CFR 220 Sub Chap H**
- **Disposal of batteries ashore**
- **Turn into the local Defense Reutilization and Marketing Office (DRMO)**
- **Or contact the local military environmental branch for disposal as hazardous waste**
- **Explosive Ordnance Disposal (EOD) shall be contacted under Emergency conditions for immediate removal to a safe site**



Lithium Battery Safety Program

Emergency Response Procedures

- **All ventings, accidents, and incidents involving lithium batteries shall be reported IAW the current version of OPNAVINST 5102.1, "Mishap Investigation and Reporting."**
 - **Reports shall also be sent to NOSSA**
- **All lithium battery-powered equipment shall have emergency response procedures**
 - **When documentation is not available, the general emergency response procedures listed below shall be followed for Naval shore facilities, ships and vessels:**
 - **Refer to the MSDS for the battery and respond accordingly**
 - **Use Personal Protective Equipment(PPE) to approach the leaking battery**
 - **Leaking liquid should be neutralized by covering the spill with baking soda, then layer an absorbent over the area until the liquid is completely absorbed**



Lithium Battery Safety Program

Emergency Response Procedures

- Sweep up absorbent and deposit in strong doubled plastic bag and place in an appropriate hazardous waste container
- Place leaking battery in a strong plastic bag and pack in an appropriate container with enough absorbent to completely absorb all liquid contained in battery
- **DO NOT PACKAGE OTHER BATTERIES WITH A LEAKING BATTERY**
- Label the outside of the container as “HAZARDOUS LEAKING LITHIUM BATTERY FOR DISPOSAL.”
- If any lithium battery electrolyte comes in contact with skin, eyes, mouth, etc., flush with copious amounts of water (for 15 minutes) and report immediately to the medical department for treatment
- Do not attempt to open or repack the original container
- Contact the Military Environmental Protection Group or (DRMO) for further information



Lithium Battery Safety Program

Swollen or Hot Lithium Battery

- **Evacuate area and contact Explosive Ordnance Disposal personnel**
- **All incidents concerning equipment damage or personnel injury shall be reported to NOSSA via an accident/injury form**
- **Actively Venting Battery, or a Fire Involving Lithium Batteries (including a fire in a location where lithium batteries are stored)**
 - **Call the Fire Department, making sure they know that lithium batteries are involved (chemistry, size and volume)**
 - **Secure the area**



Lithium Battery Safety Program

PLATFORM

CRITERIA

Subs	Venting of gaseous/liquid/solid material and flames outside of the test unit is prohibited.	and	The peak pressure remains equal to or below 50 percent of the yield pressure of the unit in any test.
Aircraft (1)	Venting of gaseous/liquid material is permitted. Venting of solid material and flames outside of the test unit is prohibited. Rupture of the test unit is prohibited.	and	The peak pressure remains equal to or below 50 percent of the yield pressure of the unit in any test.
Ships	Venting of gaseous/liquid/solid material is permitted. Venting of flames outside of the test unit is prohibited. Rupture of the test unit is prohibited.	and	The peak pressure remains equal to or below 50 percent of the yield pressure of the unit in any test.
Land	Venting of gaseous/liquid/solid material and flames is permitted. Rupture of the test unit is prohibited.	and	The peak pressure remains equal to or below 50 percent of the yield pressure of the unit in any test.
Unsafe	Rupture of the test unit	or	The peak pressure exceeds 50 percent of the yield pressure of the unit in any test.

(1) The preferred chemistry for aircraft is solid cathode chemistry. Liquid cathode chemistries are highly corrosive and toxic. The location of the cell or battery in the aircraft will be closely scrutinized, especially regarding the possibility of toxic, corrosive gases affecting crew members, passengers, or high priority equipment or systems.



Lithium Battery Safety Program

Unit Criteria (cont)

- **Batteries must not vent in response to the Electrical Safety Device Test**
- **Reaction from the battery shall not adversely affect the safety of the unit**



Lithium Battery Safety Program

Conclusion

The concept of a lithium battery encompasses a wide variety of specific characteristics

The Navy has an excellent safety record with lithium battery use, and this is the process by which we have met and will continue to maintain this record

LBSP's primary function is to minimize risk to personnel and platforms while allowing the use of lithium batteries to advance our military capabilities



Lithium Battery Safety Program

Takeaways

- 1. High voltage lithium ion battery (330V) JSF**
- 2. High cost - JSF battery system > \$70K. Handle carefully & safely**



Lithium Battery Safety Program

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Lithium Battery Safety Program

EaglePicher

MSD-920-2
MSD-970-1

NSN 6130-01-508-3397



Locker and Field Universal Solutions to Battery Servicing



Lithium Battery Safety Program

Key Common Specifications

- **Fully Automatic Battery Servicing**
- **Servicing any Secondary Battery Chemistry**
 - **Nominal Battery Voltages Between 0 and 40 Volts**
- **Programmable Battery Profiles For Future Upgrades**
- **Selectable Stored Battery Profiles For NAVAIR 17-15BAD-1**
 - **Shipped with Pre-Loaded Profiles**
 - **Store Capacity Up to 80 Profiles**
 - **Profiles Can Contain Up to 10 Operational Steps**
 - **Multiple Service Termination Criteria**
- **Capture Service Data for Analysis Through Serial Port**
- **System Contains Active Temperature Compensation**
- **120 or 240 VAC, 60Hz Operation**
- **Common Operation Training for Both Systems**



Lithium Battery Safety Program

System Differences

MSD-920-2

- **Suitcase Construction**
- **Dimensions (9" x 16" x 23")**
- **Weight (45 lbs)**
- **Charge Current (25 Amps)**
- **Discharge Current (50 Amps)**

• **MSD-970-1**

- **Metal Box Construction**
- **Dimensions (12-5/8" x 21" x 20")**
- **Weight (103 lbs)**
- **Charge Current (65 Amps)**
- **Discharge Current (70 Amps)**